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HEAT TREATMENT ANALYSIS OF THINSECTION RACES

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ABSTRACT: The paper deals with some causes – tests, where the material behavior is observed on the real parts. Sometimes is this behavior different than opposite theoretical aspects and follows the ideas or predictions…how, why etc. [1].

KEY WORDS: ball race, heat treatment, structure, deformation, hardening

1. INTRODUCTION

Heat treatment (HT) of a ball race is practice on continuous aggregates PVSA and the whole process of heat treatment maximally provides the repeatability of quality, the absence of influence of human factor which the regular tests of heat treatment confirmed (structure, through hardening, decarburization and hardness) [2]. Along this quality process, we came upon problems with races deformation, where the maximum thickness is lower than 11 mm and diameter is above 120 mm. These deformed ball races are straightened by screws and truing machines, which is quite laborious but inexpensive method. At this point, it is necessary to straighten 40 - 90 % on oval and face unflatness.

Investigation of deformed ball race has found rammed material on surface – it's the assumption of influence of ball race surfacing (from the forged piece) with big dimensional tolerances.

2. EXPERIMENT

Exams of intensity of cooling in quenching oil showed: oil producer suggests the operation temperatures of oil 60 - 130 °C, by oil Durixol W72 aggregate No.1 and by the oil OL46 50 - 120 °C aggregate No. 2.

We examined temperatures of 60 °C, 80 °C, 100 °C, 125 °C on both aggregates, with 50 ball races at every temperature.

The results were identical: 20 ball races are necessary to be straightened on oval, 10 ball races are necessary to be straightened by face unflatness, 20 ball races are necessary to be straightened on oval and face unflatness, and only in one case of oil Durixol at temperature of 125 °C we planned 2 parts less for a face unflatness.

For heating influence – by spirals – the tests were made for 200 parts. When the races came out of the aggregate they were measured for deformation (especially in area nearby the spiral). However, we didn't discover any difference in deformations of races.

Fig. 1: Races batch into aggregates

- quenching process on flat cast plates on furnace Aichelin. The exams were made on 40 parts.

Deformations were made:

- By classical hardening races – it was necessary to straighten the whole race.
- The secondary test process – the races were heated to the hardening temperature but with an absence of hardening process and then were the races put to air-cooling. Deformation was observed on 33 parts.

- The heating to the hardening temperature with an attachment caused deformations of races and attachment too. Here we came upon a problem – races were cooled in oil, but the attachment wasn't and the consequence of this hardness of race was low, because the race was heated by temperature of attachment.
Disadvantage of this test is, that we have only one quarter of production, since the attachments can be done only in one layer, which comes with higher energy consumption, high laborious by manipulation with attachments and races.

- Tests of replaced aggregate (of hardening temperature) on straightening attachment and consequence oil cooling caused time and velocity consumptions. We tested 5 parts but with no success.

- Bainite hardening decreased the content of retained austenite which is positive on the dimensions' changes. During the bearing operation but after the heat treatment races diameter increased by 0.3 mm to 0.6 mm, depending on wall races thickness. But all races were deformed and straightening isn't possible, nor is martensite hardening.

- Test of annealing influence.
There were two annealed forgings and they were compared to one annealed forging of a producer. The values and causes of annealing are shown in tables 1, 2.

Tab. 1: Results of measured values after the heat treatment

TPRM: T4CB 120/1	Oval	Face unflatness	Triangle	Number of parts straightened on oval Ordinance: 0.25	Number of parts straightened on deflection Ordinance: 0.15
1x annealed - 42 parts	0.17	0.13	0.16	6	21
2x annealed - 43 parts	0.16	0.08	0.14	6	10
difference	0.01	0.05	0.02	0	11

Tab. 2: Metallographic race spending towards the annealing experiment

TPRM: T4CB120/1	HRC in whole section	Structure in whole section	Troostit	Decarburization	Note
1x annealed (No. 55)	62.5 – 63	5A pass (PN 60104)	0 %	no decarburization	From producer, furnace FRN with forced circulation.
2 x annealed (No. 22)	63	5A pass (PN 60104)	0 %	no decarburization	Degussa furnace, in Ar with forced circulation, continuous temperature heating on 400 °C, 600 °C after 2 hours, 750 °C/5 hours. Furnace cooling to 250 °C.

Required hardness is 59 – 63 HRC [3].

- Next step was temperature's influence test and standing on temperature. We used following experiment. We chose 2 factors and four levels – temperature, time and metallographic spending. All values are shown in tables 3 and 4. Microscopic structure of spheroidizing annealing of bearing race is shown on figure 2.

Tab. 3: Experiment realization

TPRM T4CB 120/1 Factor level	Factor A [°C] -	Factor A [°C] +	Factor B Time in furnace [min] -	Factor B Time in furnace [min] +	Dimension: before HT: Ø min. Ø max. / after HT: Ø min. Ø max. Y1	Y2	Y3	Dimension values: before HT / after HT	Oval after HT Ordinance: 0.25 Y1	Y2	Y3	Dimension values of oval after HT	Face unflatness after HT Ordinance: 0.15 Y1	Y2	Y3	Values of face unflatness after HT	Oval tolerance	Face unflatness tolerance
1	810		60		-5 +2 +4 +15	-4 +1 +6 +15	-8 -2 +7 +20	-2.6 +11.16	0.11	0.19	0.13	0.11	0.15	0.09	0.10	0.11	-0,14	-0.04
2	810			110	-4 -1 -4 +18	-4 +2 +5 +10	-4 0 -10 +20	-1.8 +6.5	0.22	0.05	0.30	0.19	0.29	0.16	0.09	0.18	-0.06	+0.03
3		830	60		-4 +1 +6 +19	-4 +1 +6 +16	-5 +2 -4 +16	-1.5 +9.8	0.13	0.08	0.20	0.13	0.11	0.06	0.06	0.07	-0.12	-0.08
4		830		110	-6 +4 -8 +10	-4 0 -10 +13	-4 0 -5 +15	-1.6 +2.5	0.10	0.20	0.20	0.20	0.12	0.05	0.22	0.10	-0.05	-0.02

Tab. 4: Metallograpnic evaluation

Factor	*Required value of hardness HRC 60 – 64*			Structure of Troostit %			Decarburization		
Factor level	Y1	Y2	Y3	Y1	Y2	Y3	Y1	Y2	Y3
1	60,5-61	61	61-61,5	4A	4A	4A	0,00	0,00	0,00
2	61,5-62	62	61,5-62	4A	non responsive to etalon	non responsive to etalon	0,00	0,01	0,01
3	61-61,5	61,5	61,5-62	non responsive to etalon	4A	4A	0,00	0,00	0,02
4	61,5-62	62	61,5-62	non responsive to etalon	non responsive to etalon	non responsive to etalon	0,02	0,02	0,02

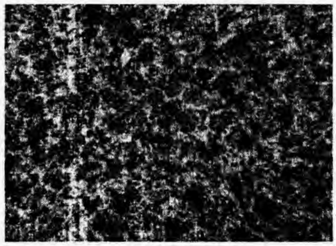

Fig. 2: Structure evaluation of bearing race (spheroidizing annealing is responding)

From all measured values and investigations, the only one we required is factor level 1, by using minimal time and minimal temperature. Minimal time is used every time, but problem on the present machine is having minimal temperature at full loading, if the temperature difference is ±10 °C in consequence of overcooling of races. Only 3 races were used during the test and we had to regularize the minimal temperature manually [3].

Nowadays is continuous solution of the deformation decrease the Six Sigma project, some partial results of which are described in this paper.

3. REFERENCES

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